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STATEMENT OF DR. GLENN T. SEABORG,[1] CHAIRMAN; JAMES T. RAMEY AND WILFRID E. JOHNSON, COMMISSIONERS; AND DR. JOHN R. TOTTER, DIRECTOR, DIVISION OF BIOLOGY AND MEDICINE, ATOMIC ENERGY COMMISSION

Chairman HOLIFIELD. Dr. Seaborg, again it is a pleasure to welcome you to the witness chair.

We are anxious to hear your statement.

You might introduce your companion here.

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[1] Glenn T. Seaborg was born April 19, 1912, in Ishpeming, Michigan. At the age of ten, he has his family moved to California. In 1929 he was valdictorian of his class at the David Starr Jordan High School in Los Angeles. In his junior year at the University of California at Los Angeles, he was named to Phi Beta Kappa, and in 1934 he received an A.B. degree in chemistry from UCLA. In 1937 he was awarded the Ph. D. degree in chemistry from the University of California, Berkeley.

Dr. Seaborg is Chairman of the United States Atomic Energy Commission, having been appointed by President Kennedy in 1961, and subsequently reappointed by President Johnson and President Nixon. He also served under President Truman, from 1946 to 1950, as a member of the Atomic Energy Commission's first General Advisory Committee, and under President Eisenhower, from 1959 to 1961, as a member of the President's Science Advisory Committee.

From 1958 to 1961, Dr. Seaborg was Chancellor of the University of California, Berkeley, having served on the faculty since 1939, and from 1937 1939 as the personal research assistant of Gilbert Newton Lewis, Berkeley's famous physical chemist. He is currently on leave as professor of chemistry.

During World War II, while on leave of absence from Berkeley, he headed the group at the Metallurgical Laboratory of the University of Chicago that devised the chemical extraction processes used in the production of plutonium for the Manhattan Project.

Among his major scientific contributions are his discoveries, between 1940 and 1958, with several colleagues, of the transuranium elements: plutonium (element 94), americium (95), curium (96), berkelium (97), californium (98), einsteinium (99), fermium (100), mendelevium (101), and nobelium (102). His co-discoveries include the fissile isotopes plutonium-239 and uranium-233, as well as the identification of more than 100 other isotopes throughout the periodic table, including a number that have practical applications in research and medicine such as iodine-131, cobalt-60, technetium-99m, cobalt-57, iron-59, iron-55, manganese-54, antimony-124.

In 1951, at the age of 39, Dr. Seaborg was awarded the Nobel Prize in Chemistry (with E. M. McMillan). In 1947 he was named by the U.S. Junior Chamber of Commerce one of America's ten outstanding young men. For his outstanding work in the field of nuclear chemistry and for his leadership in scientific and educational affairs, he was awarded the Atomic Energy Commission's 1959 Enrico Fermi Award. In 1962 he was named "Swedish American of the Year" by the Vasa Order of America in Stockholm, and in 1963 he received the Franklin Medal of the Franklin Institute of Philadelphia. The Pacific Science Center, Seattle, recognized his vast contributions to the public understanding of science by selecting him for the 1968 Arches of Science Award. He has been honored by the American Chemical Society with the Award in Pure Chemistry (1947), William H. Nichols Medal (1948), Charles Lathrop Parsons Award (1964), and Willard Gibbs Medal (1966). Dr. Seaborg holds honorary degrees from more than 30 educational institutions.

In 1959 Dr. Seaborg was instrumental in inaugurating the Chemical Educational Material Study (CHEM Study), the high school Course Content Improvement Study of the National Science Foundation, and has served continuously since then as Chairman of its Steering Committee. Since 1966 he has been president of Science Service, Washington, D.C., an organization devoted to the popularization of science.

His many activities include membership on the Federal Council for Science and Technology, National Aeronautics and Space Council, National Council on Marine Resources and Engineering Development, Scientific Advisory Board of the Robert A. Welch Foundation in Houston, board of directors of the National Educational Television and Radio Center in New York, board of trustees of Pacific Science Center Foundation in Seattle, and Advisory Board of Nova University in Fort Lauderdale.

He is the author of more than a dozen books, many of which have been translated into foreign languages. He has published over 200 scientific papers on the transuranium elements, artificial radioactivity, nuclear physics and chemistry, high energy nuclear reactions, as well as the compilation of complete tables of isotopes, and a comprehensive article on "Elements Beyond 100, Present Status and Future Prospects" in the 1968 Annual Review of Nuclear Science.

He organized and was the chief participant in the National Educational Television series of ten half-hour films on *The Elements*, produced in 1957 and still widely used in high schools throughout the country.

Dr. Seaborg is a member of the leading national and international scientific societies, including the National Academy of Sciences, American Academy of Arts and Sciences, American Chemical Society, American Physical Society, American Nuclear Society, American Philosophical Society, Royal Society of Arts (England), Royal Swedish Academy of Engineering Sciences, Bavarian Academy of Sciences, Argentine National Academy of Sciences, Spanish Royal Academy of Sciences, honorary fellow of the Chemical Society of London, and the Royal Society of Edinburgh.

Dr. Seaborg is married to the former Helen L. Griggs; they have six children.

He is an ardent sports fan. His favorite spectator sports are football and baseball. His recreational interests include hiking and golf. From 1953 to 1958 he served as Faculty Athletic Representative of the University of California, Berkeley, to the Pacific Coast Intercollegiate Athletic Conference.

Mr. RAMEY. I am a stranger.

Dr. SEABORG. Commissioner Ramey is going to follow me with his testimony this morning, if we get that far.

Chairman HOLIFIELD. If we don't, we are going to take the time to get the testimony because it is very important that we have this testimony.

Dr. SEABORG. Commissioners Johnson and Thompson are over at the far table; Mr. Shaw and Dr. Totter are at the table on my left.

Mr. Chairman and members of the committee: As I am sure you know, I am always pleased to appear before the members of this committee. I particularly welcome the opportunity to be the opening speaker for the AEC at these hearings. I think the committee has acted in a timely fashion and exercised its usual wisdom in scheduling the discussions that will be held here during the next few days.

PUBLIC INTEREST IN ENVIRONMENTAL CONDITIONS

If public interest is the criterion, then timely is exactly the word to use in describing these hearings on the Environmental Effects of Producing Electric Power. One would have to be totally cut off from civilization these days—or both blind and deaf—not to be fully aware of the public's concern with what has been broadly termed The Environment. There is hardly a day in the week, or an hour in the day, when one does not see a newspaper or magazine article, hear a radio program or view a TV show in which the subject of pollution—in terms of waste, water, air, chemical, noise or other varieties—is brought up in some way. It was pointed out to me the other day that in a Sunday edition of a nationally known newspaper, three sections alone had eight articles with 2,100 lines devoted to environmental effects. And this is typical of what we might call "the pollution press coverage" we are receiving from all media.

I submit that on an overall basis this public awareness and alarm is a very good thing. Man in general has always had a tendency towards excesses and indiscretions. Invariably such faults, whether they are manifested in matters involving his own personal life and health, or in those expressed through his society (which ultimately also affect the individual's life and health), have a way of surfacing sooner or later.

Not as wise as we think we are—or should be—we create, we apply our creations and, when they prove beneficial, we usually go overboard in our use and enjoyment of them. Inevitably there is some kind of feedback—a warning—in this process—and if we do not heed it and adjust our ways we run into trouble. This has been true throughout history. And the lessons of history seem to show that we have never been as good at foresight as we have at hindsight.

But in our new scientific and technological age, where things happen so much faster and on such a larger scale, this truth is now coming back at us with an unequaled rapidity and vengeance. So we must recognize it, we must face it, and we must deal with it. I believe we can, and will, do all three. And hearings such as these, followed by significant and cooperative action on the part of your committee and our agency and the other agencies involved, will go a long way toward accomplishing this, specifically as related to the exercise of some wisdom in planning for the future energy needs of this country.

Now, while I have emphasized the public's awareness and alarm over environmental conditions, I must express my own alarm, or at least my extreme concern, over a related matter.

I am concerned that, for all the extensive coverage of pollution, much of the public is being ill-informed and misinformed about many environmental matters. I am concerned that for every bit of valid criticism there is more than an equal amount of unsubstantiated fear-mongering. Again we are faced with a matter of excess, or at least with an imbalance, where alarm and a sense of urgency is present in abundance, but where the information, funds, time, and spirit of cooperation—all so necessary to constructive action—are not as readily at hand. Perhaps no one knows this better than the Members of Congress who deal so directly with the public's demands and also who have had brought directly to their attention the vital and relevant information on the same matters by experts in Government and industry.

I think this situation must change if we are to deal successfully with our environmental problems. We must have less hysteria, less searching for scapegoats, less polarization of conservationists and technologists, and less conflict between those engaged in the various disciplines that affect and deal with the environment. We need a more tempered sense of urgency, more knowledge, more cooperation, and much more of a positive outlook and approach.

The degrading of our environment has not been the fault of any one group or element of society. Nor will its future be determined by the action of any one segment—industry, Government, or the public. It is a task for all—and it should be. We all breathe the same air that forms such a thin and precious envelope around this unique planet. We all share the same meager 2 percent of fresh water on its surface. We all need to use the same limited resources and space this earth provides. And we all want to turn this same earth over to our children, and their children, as a clean, livable, and attractive home. I strongly believe that we can do this—not by complaining about what has been, or even what is, but by exercising a little wisdom and a lot of hard work toward what can be.

With this personal evaluation of public concern and expression of confidence over our ability to deal with environment, let me briefly and very broadly discuss nuclear power in this context, mainly to set the stage for the more detailed testimony of Commissioners Ramey, Thompson, and Larson and those other experts whose testimony you will be hearing over the next few days.

Commissioners Ramey and Thompson are here. Commissioner Larson is out of town today. Commissioner Johnson is also here and I am sure will participate in the hearings.

Representative HOSMER. Who is running the store?

Dr. SEABORG. I think the General Manager, probably, but that is not any change, I would say. [Laughter.]

GROWTH IN POPULATION AND POWER NEEDS

Dr. SEABORG. To begin with, most of us recognize today that our total environment is a close combination of both our natural world and the technological civilization we have built. Contrary to what some people are saying these days, I believe that both elements of this combination are necessary and desirable and, what's more important here, can be highly compatible. Essential to this is the constructive use of energy—energy that is readily available, abundant, economic, and that can be applied massively but with a minimum of impact on the environment. We must also face the fact that a growing world population with both rising standards of living and volatile rising expectations will demand a huge amount of power in the years ahead. By the year 2000, this country will require the production of 130 quadrillion British thermal units of all types of energy per year to supply the wants of 300 million people.

Chairman HOLIFIELD. Can you compare that with what we are using now?

Dr. SEABORG. Yes. It is about eight times what we are using now in terms of electric power consumption and twice what we are using in terms of total energy consumption.

The world will need many times this number. Assuming world use at one-quarter of the U.S. per capita consumption, this would, in the year 2000, amount to 650 quadrillion British thermal units of energy needed for 6 or 7 billion people, a staggering total.

There is no doubt that a large amount of this energy, particularly in terms of oil for the transportation and power fields, is going to come from fossil fuels over the next few decades. But in spite of forecasts of large reserves, we know that these natural resources are limited. We also know that there is a limit to nature's ability, and our own human tolerance, to absorb all the pollution that would result should we try to burn up all these fuels over the next century or so. I am not going to document the pollution loads that would accrue from the combustion of that massive amount of fuel. I think the members of this committee have many times been made aware of these amounts and their consequences. Fortunately, we have for the generation of electric power an alternate fuel—nuclear energy.

As I have said on other occasions, I believe that nuclear energy has arrived on the scene—historically speaking—in the nick of time. I base this belief on several factors:

1. The projected demand for power based on population growth and increasing per capita consumption of electricity, which was detailed by Mr. Brown.

2. The need for a cleaner and more manageable source of energy to reduce the degradation of the environment.

3. The need also for abundant and very economic energy in a world of diminishing natural resources where such energy may well determine how many people can be supported and at what living standard.

Let me expand briefly on each of these.

The current electric generating capacity of the U.S. is about 325 million kilowatts. If we look ahead a mere 30 years to the year 2000 our projected capacity is about 1.5 billion kilowatts. What is required in the way of generating facilities and fuel to keep such a capacity operating? As a hypothetical illustration of the magnitude of this requirement, consider a power economy derived solely from coal. Fifteen hundred generating plants, each with a capacity of 1 million kw. and operating at an assumed three-quarters load factor, would have to burn about 10 million tons of coal per day. Such a requirement, by the way, would involve the daily movement of 100,000 railroad cars and the dumping of coal into billions of cubic feet of storage space. Should we go the nuclear route to generate the same amount of electricity, roughly the same number of nuclear plants would consume all of 3 tons of fissionable material per day. And I might add the nuclear plants using such fuel would require reloading only once every 2 or 3 years.

What I have just pointed out, let me remind you, involves only 1 day's generation of electricity and only 30 years from today. I do not think, therefore, that anyone can seriously believe we could rely on coal as our major source of power as we enter the 21st century, or that we should not develop with all due urgency the best systems for producing nuclear power.

Even if our projected coal reserves should be sufficient to fill our furnaces for a few centuries, long before we dig for that last lump of coal we will have far better uses for this valuable resource than to burn it. Here I have reference to its use as a unique source of material for the chemical industry. From this standpoint alone, I think the advent of nuclear energy will prove to be a historical necessity for man.

The same thing, I think, will hold true from an environmental standpoint. The pollution load that would result from the burning of all the fossil fuels, in the massive amounts and as rapidly as we would need them going into the next century, would pose a disastrous environmental hazard. I am thinking here, as I believe we must when we speak of long-range future energy requirements, on an international scale. In considering such requirements, we must recognize that there is a world of 2 billion people—and rapidly growing—outside of the developed world, and that these people are striving for a life that will demand an energy consumption on a scale with ours.

This thought becomes staggering when one considers that at present 2 billion people in the world still have no electricity, and Asia, with half the world's population produces only one-tenth of the world's total electric power. In raising their standard of living, these people cannot and will not relive our industrial revolution—the coal age. They obviously are going to enter the nuclear age as they work to emulate the developed nations.

Let me state at this point that my remarks related to coal do not mean that I think we can get along without it. Coal will continue to be essential to our lives for decades. And I believe we would be wise to consider coal and the atom as energy partners, not competitors. But the day has passed when we can look ahead only a few decades and complacently wait for the depletion of each of our resources before we move ahead to compensate for them.

DEPENDENCE ON NUCLEAR POWER

Now, since we are eventually going to live in a world that will have to depend on the energy of the atom, we must learn to live with the atom wisely. This means we must recognize, anticipate and deal with all the environmental aspects and prospects of nuclear energy. I believe we are doing this, and doing it well. This type of technological development is something that has never before been attempted in the history of man. No technology has been born and developed with the regard for human safety and well-being that is inherent in the development of nuclear energy.

In fact, you might say that the extent of our knowledge about the biological aspects of nuclear energy has been a problem to us—or at least to those in the nuclear field who are impatient. The tremendous amount of knowledge we have accumulated over some 20-odd years has made us almost overly conservative in the development of nuclear power. I have often thought that if the potential health and safety implications of so many aspects of our lives—our chemical products, our foods, our transportation systems, our athletic activities, even our sleeping habits, to name a few—were so well-known and documented, we would have a very apprehensive public—literally afraid to eat or drink anything or go anywhere or do anything.

Fortunately, because of our knowledge of nuclear energy, and the way we have developed it in accordance with that knowledge, we have at hand a unique opportunity to advance an abundant source of power with a minimum of environmental impact. We are following such a course, fulfilling such an opportunity.

The environmental problems associated with the growth of nuclear power—the control of radioactive effluents and thermal effects—will be covered in detail by those who will follow me in these hearings.

I will only say at this point that all that I have seen and heard, my total experience in the nuclear energy field for more than a quarter of a century and my association with others who have devoted their lives to this field, has given me the firm conviction that the environmental problems associated with nuclear energy are manageable. With good planning and continued dedicated work on the part of those in the nuclear field, our electric utilities and those Government agencies that regulate our Nation's power systems, we can have safe, clean and reliable nuclear power—as much of it as we will need.

The suggestions I have made earlier of vast benefits that can be derived for mankind from nuclear energy were not made without full awareness that there are inherent in this technology certain risks and potential hazards to health and safety, as there are risks in many other activities. Recognition of the fact of these risks is the basic reason for the comprehensive system of safety review and regulatory controls set up by the Congress for the protection of people and the safety of the reactor facilities and for the extensive programs of safety research in both the physical and biological aspects of nuclear power plants and radiation.

In spite of the current wave of misunderstanding and fear registered by a certain segment of the public, I think we are going to prove this important point—that the benefits related to nuclear power will outweigh the risks involved by a factor far greater than most of our modern technologies can boast.

There will be continuous agitation, there will be adjustment and compromise—more important, there will be more understanding and a better working relationship between reasonable and rational environmentalists and technologists who will see that they are not as far apart as they believe. As a result, we will see in the long run more nuclear power and a healthier environment.

When we have gotten past this point, I believe we are going to see some remarkable things happening with nuclear power. We will find, with good site planning and the esthetic designing of nuclear plants, that nature and technology are not incompatible. We may well see the advent of "Nuclear Parks" advocated by members of this committee. We could see the use of abundant and very economic nuclear energy having a widespread beneficial effect on many other environmental problems—helping us to supplement and control our water resources, helping us to recycle much of our solid waste, thus preserving our diminishing mineral resources and eliminating many eyesores and environmental blights on our landscape. And we will ultimately see this kind of nuclear energy having a remarkable effect on world development, helping to lift billions of energy-starved individuals into the mainstream of the 20th century.

Perhaps the most disturbing thing about the current reaction to environmental problems is the attitude it is engendering—a fear that is making many look backwards. There are some people whose only reaction to the possibility of future power shortages—and "blackouts" and "brownouts"—should we fail to plan and build now to meet our future needs, is that we should reduce our use of electricity, turn out our lights. There are others who are so irrational in their fear of nuclear power, and so desperate for alternatives, that they have seriously advocated harnessing the Gulf Stream, or icebergs, or volcanoes, or hot air balloons. Fortunately, most people are not willing to sit in the dark, or search in the dark for a better life for themselves and their children.

We who are involved in developing nuclear power to provide for future electricity needs are naturally disturbed by that public resistance which seeks to halt or slow down such development. However, along with our obligation to safeguard the natural environment we also have a responsibility to help supply our people with the power to run a technologically sustained society. In the years ahead, today's outcries about the environment will be nothing compared to cries of angry citizens who find that power failures due to a lack of sufficient generating capacity to meet peak loads have plunged them into prolonged blackouts—not mere minutes of inconvenience, but hours—perhaps days—when their health and well-being and that of their families, may be seriously endangered.

The environment of a city whose life's energy has been cut, whose transportation and communications are dead, in which medical and police help cannot be had, and where food spoils and people stifle or shiver while imprisoned in stalled subways or darkened skyscrapers—all this also represents a dangerous environment that we must anticipate and work to avoid.

Among those who are opposing nuclear power on the grounds that we are too affluent in our use of energy and could afford to cut back are many whose motives are sincere but who have not thought things through. For more often than not, these are the very same people who rightfully want to lift their less fortunate fellow humans from poverty, who want to build new cities, new schools and new homes, who want to produce more food for the hungry and want to achieve other social and human goals for more people. Such accomplishments invariably will call for the use of much more energy than we have at hand today. The self-sacrifice of turning out some lights or unplugging some appliances is not the way to bring a better life to those growing millions who need and want the benefits brought through more energy.

In conclusion, let me go back to a little bit of light that was shed by a wise man who wrote long before this nuclear age, but still at a time when men struggled with their thoughts and actions about the future. Almost two centuries ago, Edmund Burke wrote:

> The public interest requires doing today those things that men of intelligence and good will would wish, five or 10 years hence, had been done.

I believe that the judicial development of nuclear power as a major source of energy for the future is in the public interest and that 5, 10 and 100 years hence, men will look back with favor on the course we are taking today.

Chairman HOLIFIELD. Thank you, Dr. Seaborg.

That is one of the finest statements that you have ever made before this committee, in my opinion. It puts a perspective on the problems that face us which few of us have the ability to express as well.

Representative HOSMER. If the good doctor keeps up this kind of erudite eloquence, he is going to win a Nobel Prize for literature or philosophy. [Laughter.]

Chairman HOLIFIELD. I think he would deserve it if he gets it.

There are a few questions I think we want to ask you some questions.

You have certainly painted a picture of the potential need and reason for increased energy. The other side of it, of course, is the long and laborious problem of research and development which we face and which I regret to say has been drastically cut.

BREEDER REACTOR

The solution of the problems which you point out here, the problems of adequate energy, I believe must be solved. I think one of the factors of that solution is the development of the breeder reactor in order that we might magnify many thousandfold the store of energy that we now are getting out of uranium in a very inefficient way considering the amount that is available there.

I wish you would comment on that and also on the problem of protecting the people of this country from any possible biological damage from such operation.

Dr. SEABORG. I would be glad to.

I think that we definitely need to develop the breeder reactor. This is a necessity, of course, in order that we might use our nuclear fuel efficiently and have sufficient fuel to produce this nuclear electricity that I projected for the future.

Chairman HOLIFIELD. Can you for the benefit of the record, for those people who are not able to attend the hearings, explain what we mean by the breeder reactor in as short and concise terms as possible?

Dr. SEABORG. I will try.

Natural uranium contains only seven-tenths of 1 percent of a fissionable type of uranium, uranium-235. That is our national heritage of nuclear fuel.

A nuclear power reactor can operate and produce heat energy, which is converted to electricity in a nuclear powerplant, operating on this natural uranium under proper geometrical arrangements. Most nuclear powerplants operating in the United States today, and projected for about the next 10 years, operate not on natural uranium but slightly enriched, slightly modified natural uranium, uranium in which the proportion of uranium-235 has been multiplied by a factor of 3 or 4.

Chairman HOLIFIELD. First separated from the natural?

Dr. SEABORG. First separated in our gaseous diffusion plants, enriched to a concentration of perhaps 3 or 4 percent. This, however, is still, from the long-range viewpoint, an inefficient use of the uranium because it doesn't exploit the remaining 99.3 percent which is nonfissionable uranium-238. However, we refer to uranium-238 as a fertile isotope because it can be transformed by neutron absorption to a fissionable isotope, plutonium-239.

A breeder reactor is a machine especially designed and constructed so that it can produce heat through the fission reaction under conditions where there is an excess of neutrons so that fertile uranium-238 can at the same time be transmuted to fissionable plutonium-239. A breeder is defined as a reactor where more plutonium-239 produced by conversion of fertile uranium-238 to fissionable plutonium-239 than is consumed in the nuclear fuel that is furnishing the energy produced by the reactor.

In addition to the conversion of uranium-238 to plutonium, to produce more plutonium in the type of breeder that operates eventually on plutonium, we also have the prospect for operating essentially the same kind of cycle with thorium. Starting with some fissionable material—it can be uranium-235 or plutonium or uranium-233—thorium-232, which is a fertile material, can be transmuted to fissionable uranium-233. A thorium-uranium-233 breeder is one in which the amount of fissionable uranium-233 produced by transmutation from fertile thorium-232 is greater than the amount of fissionable fuel consumed in the process. In both cases, as this process goes on fission heat is generated which is transformed into electricity.

In the case of the uranium 238-plutonium 239 cycle, this operates best and most economically from the standpoint of conserving neutrons to get a breeding ratio of more than one—which is required—if we use fast neutrons, that is, neutrons with energies essentially unchanged, or only slightly changed from the energy spectrum at which they are emitted in the fission reaction.

In the case of the thorium-232-uranium-233 cycle, that operates better with slow neutrons. You get a breeding ratio of more than one if you reduce the energy of the neutrons to thermal energies.

Chairman HOLIFIELD. Thank you for that explanation.

Now will you give me, in one sentence, what the result of that would be if we are successful in reaching this goal in terms of multiplication of energy from this more efficient use of uranium and the time period in which our uranium supply would last?

Dr. SEABORG. Yes.

This would multiply the energy that it is possible to obtain from uranium as a minimum by a factor of 100 or more, that is the ratio of the abundance of the uranium-238 to uranium-235. But, in actuality, the factor is much more than that, thousands and tens of thousands, because the cost of the fuel is so much less when you use all of it that you can afford to mine much lower grade uranium. The net effect is that you have increased your potential fuel by factors of 10,000, a hundred thousand, depending on how long a period you are talking about.

Representative HOSMER. Mr. Chairman.

Chairman HOLIFIELD. Mr. Hosmer.

Representative HOSMER. Academician Lev Artsimovich, stated that we are now halfway to the Eldorado of abundant cheap electricity in the form of nuclear fusion.

Why should we bother with the breeder reactors on the way if that halfway statement means anything in terms of a short number of years?

Dr. SEABORG. It is, of course, an imprecise term to try to define just how far along the road we are. Perhaps halfway isn't too bad an estimate.

Representative HOSMER. It depends on half of what?

Dr. SEABORG. But it is a long ways to go, I was going to say.

I still say we probably have a number of decades before we can solve all of the problems attendant with building a large fusion reactor, a reactor that produces more energy than it consumes and is within the bounds of some economic reality.

Representative HOSMER. So the breeder is indeed a necessary interim step?

Dr. SEABORG. In my opinion, the breeder is indeed a necessary interim step.

Representative HOSMER. Some people have attributed statements to Dr. Edward Teller that it is questionable whether the breeder can be achieved at all and that it would be dangerous if achieved, and also are attributing inference to a magazine article in "Combustion" magazine for July of this year that the prospects of breeder reactors are "dubious."

Would you comment on these inferences, allegations, rumors, whatever they are?

Dr. SEABORG. I have heard these and I have talked to Edward about them. In my direct conversations with him, I do not detect that degree of pessimism at all. I think that is my simplest answer.

Representative HOSMER. These things have some urgency and I would suggest that a simple but more complete answer might be appropriate.

Would you like to furnish it for the record.

Dr. SEABORG. I think that would be better because I don't recall everything that Edward Teller has said.

Representative HOSMER. And the same on the "Combustion" magazine article?

Dr. SEABORG. Yes; we will be glad to do that.

(The information referred to follows:)

SUPPLEMENTARY INFORMATION REGARDING DR. EDWARD TELLER'S VIEWS AND A COMBUSTION MAGAZINE ARTICLE ON BREEDER REACTORS

Over many years, Dr. Teller has expressed many opinions and made many statements regarding nuclear power. The AEC has had a number of exchanges of views with him on matters related to nuclear power's development, safety, and application, and these discussions are continuing. Some people have chosen to